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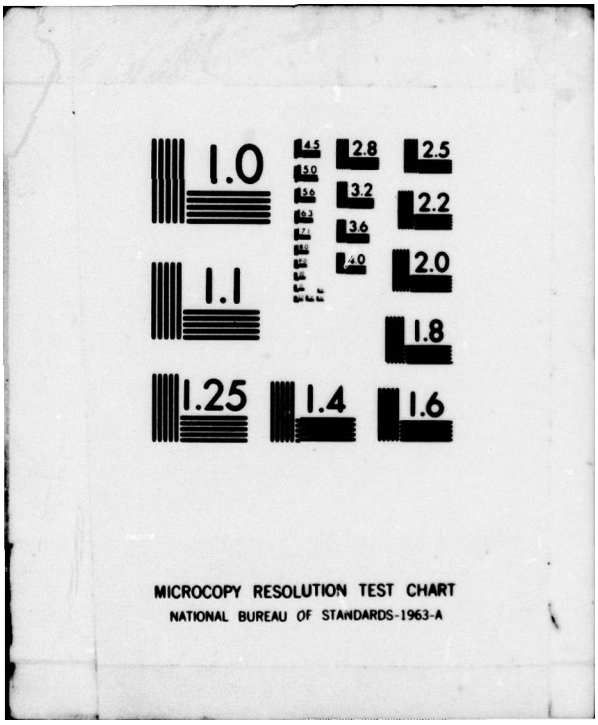
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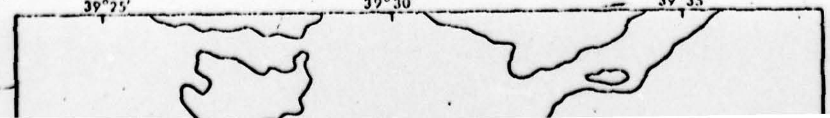

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This study described the blue crab population in the C & D Canal and adjacent areas. It was found that crabs pass thru the canal and there is a strong relationship between initial tide direction and direction of migration.

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APPENDIX V.

Blue Crabs in C and D Canal Region[1/]

Stephen D. Sulkin

Robert E. Miller

Natural Resources Institute

Chesapeake Biological Laboratory

University of Maryland

Center for Environmental and Estuarine Studies

1/ Contract No. DACW-61-71-C-0062, Army Corps of Engineers, Philadelphia District

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OBJECTIVES

The objectives of the blue crab studies in the Chesapeake and Delaware Canal project are as follows:

1) to describe the blue crab population in the C and D Canal and adjacent areas in terms of density, population structure, and general behavior;
2) to determine the extent to which the Canal is used by blue crabs in migrations between the Chesapeake and Delaware Bays;
3) to determine what effect enlargement of the Canal will have on the blue crab population.

The blue crab program involved two studies: (1) a survey effort to describe the population on a seasonal basis, and (2) a tagging program to document migrations in the region.

PART I. SURVEY STUDY

Material and Methods

In November 1970, a preliminary survey of the Canal region was made under the direction of Mr. Robert Lippson. At this time, stations were selected and techniques developed for the study. Permanent station sites were later modified slightly to coincide with the finfish survey effort. The permanent stations are shown in Fig. 1. For purposes of analysis, the stations are divided into three general regions--Elk River, C and D Canal, and the Delaware River.

Sampling gear consisted of a 25-ft otter trawl with a 1/4-in mesh liner, and a 42-in lined oyster dredge. The gear was towed simultaneously by the R/V ORION for a distance of 1/2 mile. Crabs were sized (carapace width) and sexed. At the end of each haul, top and bottom water salinity

and temperature were recorded, as well as weather conditions, station depth, bottom type, and tide condition.

The data was processed in three ways. The number of crabs caught per-square-meter of bottom sampled was calculated as a measure of relative population density. Size-frequency distributions were calculated for three size classes (0-59 mm, 60-119 mm, and over 120 mm in carapace width) in order to determine the general age structure of the population. Sex ratios were calculated for the entire catch for each sampling period.

Surveys were conducted during the following times: March 1971; June 1971; August 1971; September 1971; December 1971; March 1972; June 1972; and August 1972.

Results

Catch density for each sampling period is shown in Table 1, for each of the three identified regions. During the cold weather months of March 1971 and 1972, and December 1971, the catch was near zero for all regions. During the warm months of 1971, there were substantial catches in all regions, especially the Elk River. In constrast, during the warm months of 1972, the catch was relatively low.

Table 1. Catch (# crabs/m^2) for each of the three sampling regions.

		Month				
Location	Year	March	June	August	September	December
Elk River	1971	0	3.4×10^{-3}	3.9×10^{-3}	1.8×10^{-3}	5.2×10^{-5}
	1972	0	7.2×10^{-5}	5.8×10^{-4}		
C & D Canal	1971	0	6.3×10^{-4}	1.2×10^{-3}	8.5×10^{-4}	0
	1972	0	3.9×10^{-5}	3.1×10^{-5}		
Delaware R.	1971	0	1.2×10^{-3}	2.9×10^{-3}	3.1×10^{-4}	0
	1972		Not sampled	Not sampled		

Size-frequency distributions for the five warm-weather sampling months are shown in Table 2 for each of the three regions. The three 1971 months are most instructive because of the relatively large sample sizes. It is apparent from this data that small and medium-sized crabs (sub-legal size) greatly predominated. The Elk River seems a particularly favorable site for these small crabs.

Table 2. Size-frequency distributions for each sampling region (N=total # crabs caught).

Region	Size Classes (mm carapace width)	Sampling Period				
		June 1971	Aug. 1971	Sept. 1971	June 1972	Aug. 1972
Elk River	0-59	0.373	0.226	0.157	0	0.114
	60-119	0.584	0.638	0.575	0.170	0.499
	120 & above	0.043	0.136	0.269	0.830	0.386
		N=279	N=221	N=134	N=6	N=44
C & D Canal	0-59	0.188	0.073	0.079	1.000	0
	60-119	0.750	0.691	0.790	0	0
	120 & above	0.062	0.236	0.132	0	1.000
		N=16	N=55	N=38	N=1	N=1
Delaware River	0-59	0.458	0.026	0.222		
	60-119	0.542	0.539	0.500	not	not
	120 & above	0	0.435	0.277	sampled	sampled
		N=24	N=39	N=18		

Sex ratios for each of the three size classes in each sampling period are shown in Table 3. With the exception of June 1972, when the catch was very small, males predominated in all size classes.

Table 3. Sex ratios (Male/Female) for each of the three size classes for each sampling period.

Sampling period	Size Class (carapace width)		
	0-59	60-119	120 and above
March 1971	*	*	*
June 1971	2.250	2.207	12.000
Aug. 1971	5.750	3.104	1.900
Sept. 1971	5.000	4.684	5.286
Dec. 1971	*	*	*
March 1972	*	*	*
June 1972	1.000	0.429	10.000
Aug. 1972	4.000	3.600	16.000
Cumulative	3.000	2.847	3.767

* sample size = 0

Mean temperature and salinity data for all stations in each sampling period are shown in Table 4. Note that both salinity and temperature values for June 1972 are lower than those of June 1971. These values were measured one week prior to Tropical Storm AGNES.

Table 4. Mean temperature and salinities for each sampling period.

Sampling period	Temperature (°C)	Salinity (o/oo)
March 1971	5.6	1.9
June 1971	25.9	2.2
Aug. 1971	25.0	1.5
Sept. 1971	26.3	*
Dec. 1971	4.4	2.3
March 1972	5.4	1.9
June 1972**	23.1	0.6
Aug. 1972	24.8	1.9

* not measured
** sampled one week before Tropical Storm AGNES.

Conclusions

The evidence suggests that a seasonal migration of blue crabs occurs in the Canal region. In the winter months, the catch is reduced to near zero. Since that is the time when our dredge should be most effective, the absence of catch probably accurately reflects a low abundance of crabs. It has been reported that a combination of low salinity and low temperature greatly reduces osmoregulatory effiency in crstacea. It is likely, therefore, that as temperatures drop in the late fall, the crabs migrate out of the region to areas of higher salinity. As the water warms in the spring, the region is re-inhabited. This sequence is well-illustrated by the data from March 1971 through March 1972. The number of crabs returning to the region in the early summer of 1972 was markedly below that of 1971, as evidenced by the catch data. As was previously mentioned, both the temperature and salinity were lower in June 1972 than in June 1971. The cool,

wet spring may have delayed migration up the Bay. The drastic effects of Tropical Storm AGNES in late June makes further interpretation difficult.

The predominance of small crabs in the region is of interest. It probably reflects the value of the Elk River as a nursery ground for young crabs. It also raises the question as to where young crabs come from--the Delaware River or Chesapeake Bay?

The predominance of male crabs, even in small size classes, may offer some new information on crab migratory behavior. The widely accepted theory on crab migration is that young crabs of both sexes spread throughout the Bay. After the females reach sexual maturity, they migrate down to the high salinity areas near the mouth of the Bay, leaving the upper Bay areas to the males. The evidence presented here suggests a separation of the sexes even during their early growth stages, with the males moving further up the Bay into areas of low salinity.

PART II. TAGGING STUDY

Materials and Methods

Between June 5 and June 16, 1972, 811 crabs were tagged and released at six sites in the C and D Canal region. Figure 2 shows the six release sites. Table 5 details each site. Each crab was measured, sexed, and tagged. The stage of tide at the release site was noted, along with the temperature and salinity of the water.

Table 5. Release sites for C and D Canal tagging program.

Release site		Latitude	Longitude
1	Reedy Island Bar, Delaware	39°29'45"	75°34'00"
2	Chesapeake City, Maryland	39°32'08"	75°46'50"
3	Western mouth of C & D Canal	39°31'51"	75°51'10"
4	Elk River mouth	39°26'50"	76°00'25"
5	Elk River - Piney Creek Cove	39°30'23"	75°54'45"
6	Eastern mouth of C & D Canal	39°33'35"	75°33'00"

Two types of tags were used. Large crabs were tagged with a strip tag which stretches across the back and is wired to the lateral spines. A strip tag will be lost when the crab molts. A second type of tag, which we call a dart tag, was developed by Mr. Robert Miller for this program. It is inserted at the junction of the cephalothorax and the abdomen. This point is the so-called "buster" line--the point at which the old carapace splits and the soft crab emerges. Since the dart tag is imbedded in muscle tissue, it is retained during the molt and is an ideal tag for juveniles. Figure 3 illustrates both the strip and dart tags.

Recapture depended upon commercial and sports fishermen. A one-dollar reward was offered for the return of tags. The program was advertised in trade publications and newspapers.

Results

As of September 19, 1972, a total of 15 tags had been recaptured. This represents just less than a 2% return. Although this value is low, it should be remembered that the area is not intensively fished by either sports or commercial crabbers, and Tropical Storm AGNES may have further reduced fishery activity in the region. In addition, we have been informed that some commercial fishermen have collected several tags and are holding them until the end of the season. Consequently, the number of returns may increase markedly in the coming months.

Of the 15 returns, only one was a strip tag and 14 were dart tags. Several of the dart-tagged crabs had obviously molted since release.

The numbers of each size class released and recaptured are shown in Table 6. The predominance of medium to large crabs that were released reflects the method of initial capture (commercial fishermen's crab pots).

The higher percentages of large crab returns similarly reflects the fact that most returns by commercial crabbers or sports fishermen who were only keeping the larger crabs.

Table 6. Nos. of crabs of each size class released, recaptured, and the percent recaptured.

Size class (mm carapace width)	# Released	# Recaptured	% Recaptured
1-19	0	0	0
20-39	0	0	0
40-59	16	0	0
60-79	43	0	0
80-99	41	0	0
100-119	364	10	2.7
120-139	279	2	0.7
140-159	63	2	3.2
160-179	5	1	2.0
180 and above	0	0	0

Table 7. Recapture data (refer to Table 5 and Fig. 2 for description of release sites).

Release Site	Tag #	Recapture Site	Minimum Distance (naut.miles)	Days Elapsed	Movement Related to Initial Tide	Movement Related to Canal
1	00672	Smyrna, Del.	12	14	with	away
	00659	Port Morris, N.J.	48	15	with	away
2	7311	Pooles Is., Md.	27	7	with	west in Canal
	00626	Chansey Cr.,Del.	17	27	against	east in Canal
	00003	Smyrna, Del.	11	35	with	east in Canal
3	00214	Pooles Is., Md.	23	30	against	away
	00236	Arnold Pt.Shoal,Del.	15	30	with	east thru Canal
	00242	Arnold Pt.Shoal,Del.	15	33	with	east thru Canal
4	00030	Plum Pt.,Md.	13	26	against	away
5	00352	Swan Pt. Bar, Md.	30	17	with	away
	00058	Arnold Pt.Shoal,Del.	37	23	against	east thru Canal
	00607	Prospect Bay, Md.	50	50	with	away
6	00507	Honga, Md.	97	27	with	west thru Canal
	00115	Tilghman's Is.,Md.	84	55	with	west thru Canal
	00012	Ship John Light,Del.	17	23	with	away

Although the return was small, some tentative conclusions are possible. Table 7 shows the pertinent recapture data for the 15 crabs. Of the three crabs released in the Canal at Release Site 2, one moved west and one east

with the initial tide flow; one moved east against the initial flow. Of the six crabs released at either end (mouth) of the Canal (Release Sites 3 and 6), four moved through the Canal with the direction of the initial tide; two moved away from the Canal; one with the tide, one against it. Of the six crabs released at points removed from the Canal (Release Sites 1, 4, and 5), only one passed through the Canal, in a direction against the initial tide.

Figures 4 through 9 illustrate the crabs recaptured from each of the six release sites.

Conclusions

Crabs can and do pass completely through the Canal from either side. There seems to be a strong, positive relationship between initial tide direction after release, and ultimate direction of migration. Almost all of the crabs recaptured had migrated out of the Canal region. This was likely due to the previously mentioned recapture bias (commercial fishermen) and to the heavy flow associated with Tropical Storm AGNES.

Although it is apparent that crabs pass through the Canal, probably with the current, the data is not sufficient to determine whether the Elk River summer population can be recruited from the Delaware side and whether the Canal is a significant avenue for dispersal.

SUMMARY

Objective 1: to describe the blue crab population in the C and D Canal and adjacent areas in terms of density, population structure, and general behavior.

(a) Crabs are found in the entire area during the warm months of the year; during cold months, they apparently migrate out of the region.

(b) Densities of crabs caught in the region varied considerably between 1971 and 1972. Densities were much lower in 1972, perhaps due to salinities and temperatures that were lower during this period, as compared to 1971.

(c) Population structure consists of a predominance of small and medium-sized individuals (120 mm carapace width). The Elk River seemed to be a particularly favorable nursery ground.

(d) An approximately three to one male/female ratio was measured for all size classes. An exception was noted during June 1972 when density values as well as the male/female ratios were lower rhan in other sampling periods.

Objective 2: to determine the extent to which the Canal is used by blue crabs in migrations between the Chesapeake and Delaware Bays.

(a) Preliminary results from tagging experiments suggest that crabs do pass through the Canal in both directions.

(b) Direction of movement may be influenced by direction of water flow in the Canal.

Objective 3: to determine what effect enlargement of the Canal will have on the blue crab population.

(a) Two potential areas of impact include (1) alterations in the character of the Elk River which might affect its value as a nursery ground and,(2) alterations in the flow pattern of the Canal which affect recruitment of small crabs to the Elk River from the Delaware Bay.

(b) There is no evidence in the preliminary results to suggest that enlargement of the Canal will adversely affect the blue crab population.

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We wish to express our appreciation to Captain Martin O'Berry and Captain Bill Keefe, of the R/V ORION. We are indebted to a number of the staff of the Chesapeake Biological Laboratory for their assistance in the field work, including Mr. Brooke Gray, Mr. Tom Johnson, and Mr. Leo Minasian. We express our appreciation to Captain Larry Simms, of the party boat, DAWN, whose expertise and service greatly aided our tagging efforts. A special note of thanks to Dr. T. S. Y. Koo, whose support and advice made the blue crab study possible as part of the Chesapeake and Delaware research program. The figures were prepared by Fran Younger.

Fig. 1. Permanent sampling stations.

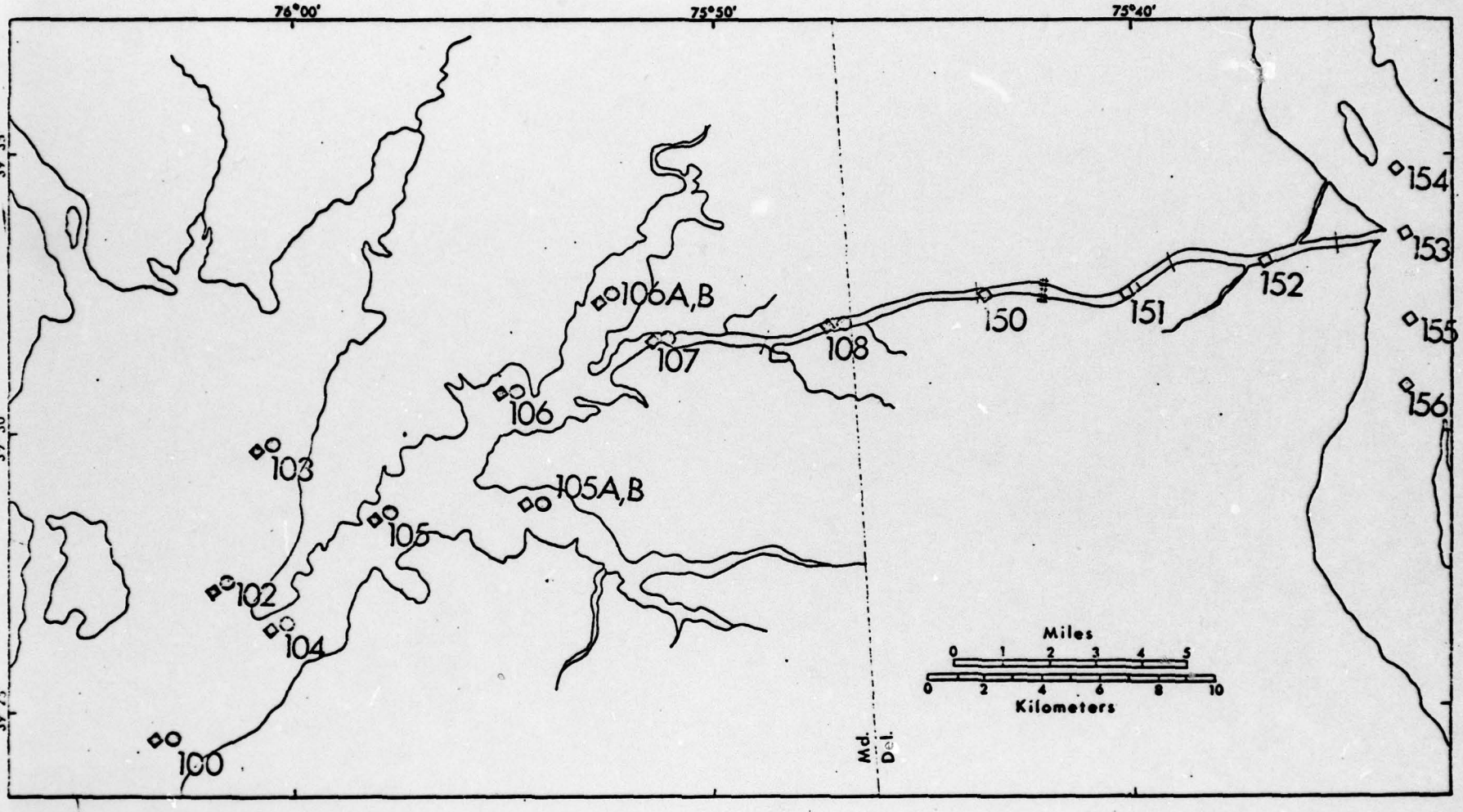
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Fig. 2. Release sites in tagging program.

Release Sites for Tagged Crabs

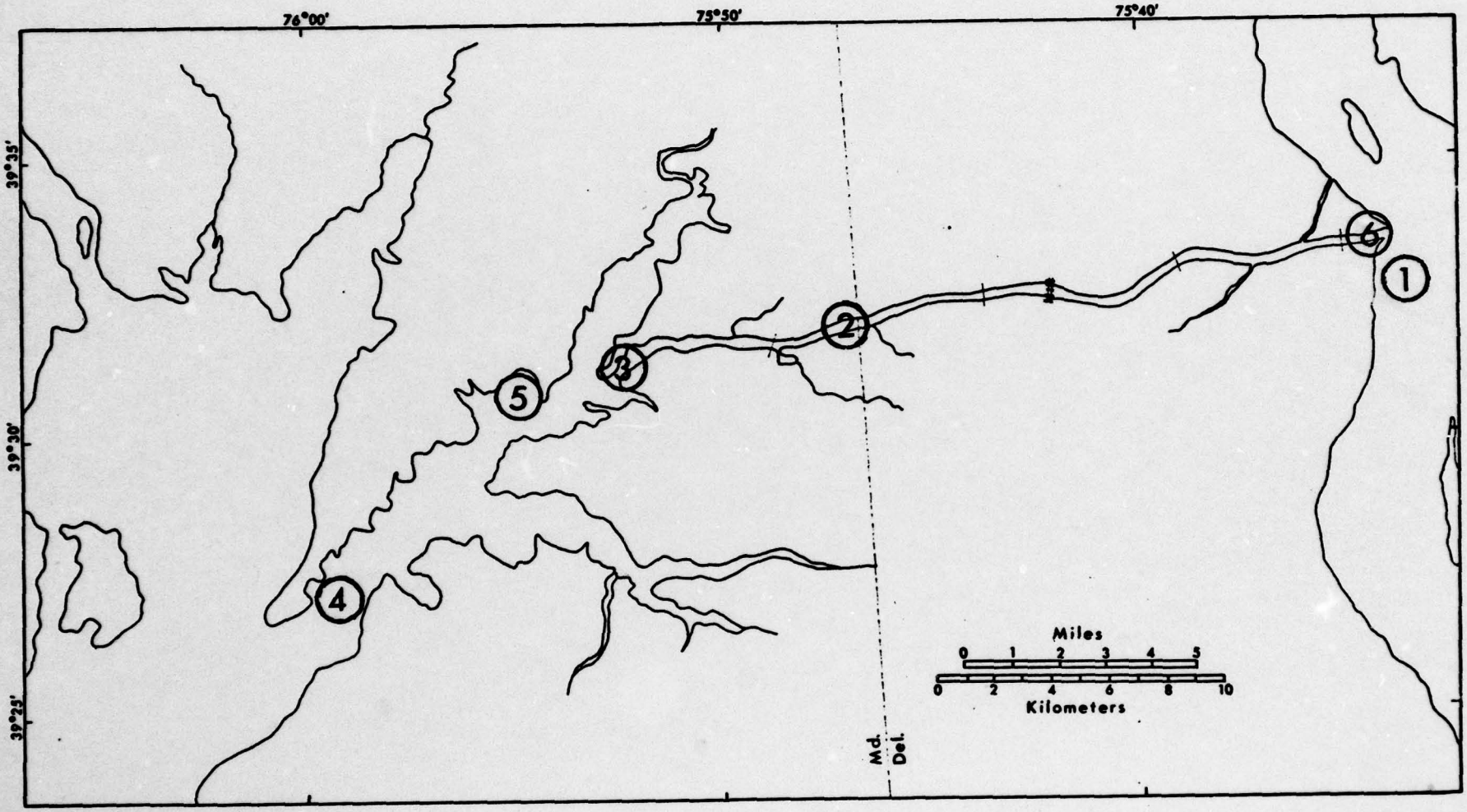

Fig. 3. Illustration of strip tag and dart tag.

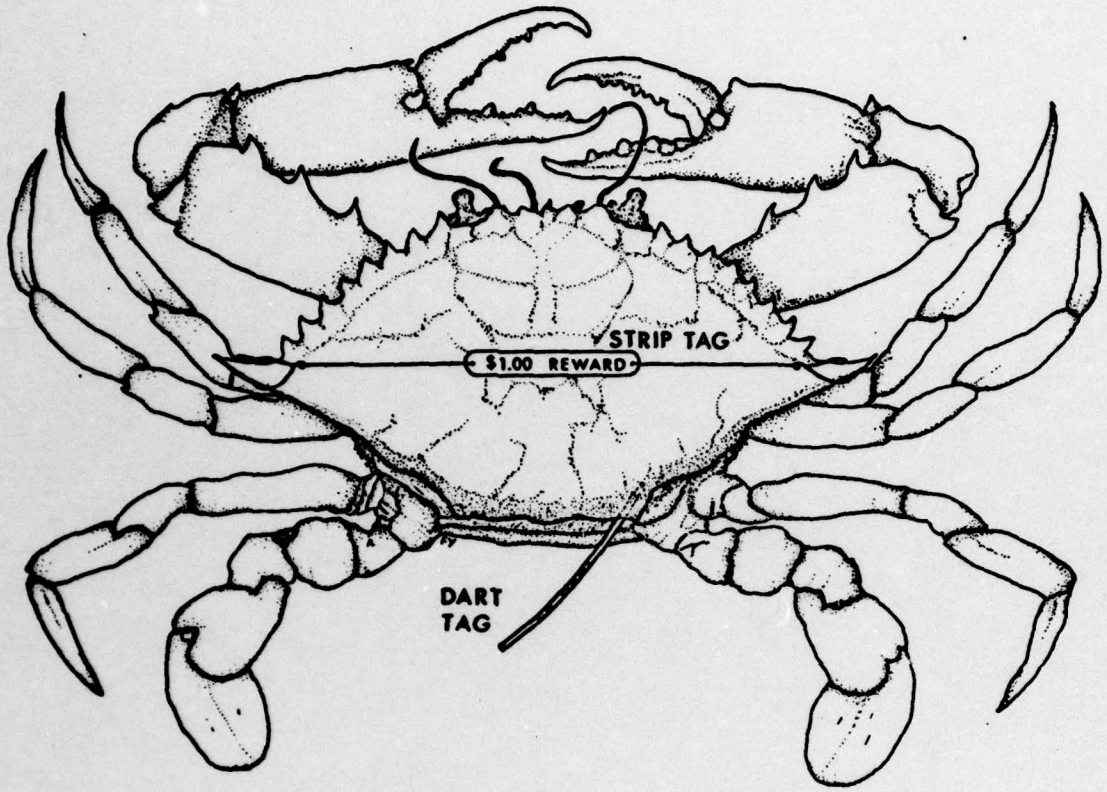
STRIP TAG
$1.00 REWARD
DART
TAG

Fig. 4. Map showing results of recapture for crabs released at Site #1. Point of release marked by heavy circles; recapture sites marked by thin circles.

Release Site 1
Reedy Island Bar Delaware Bay

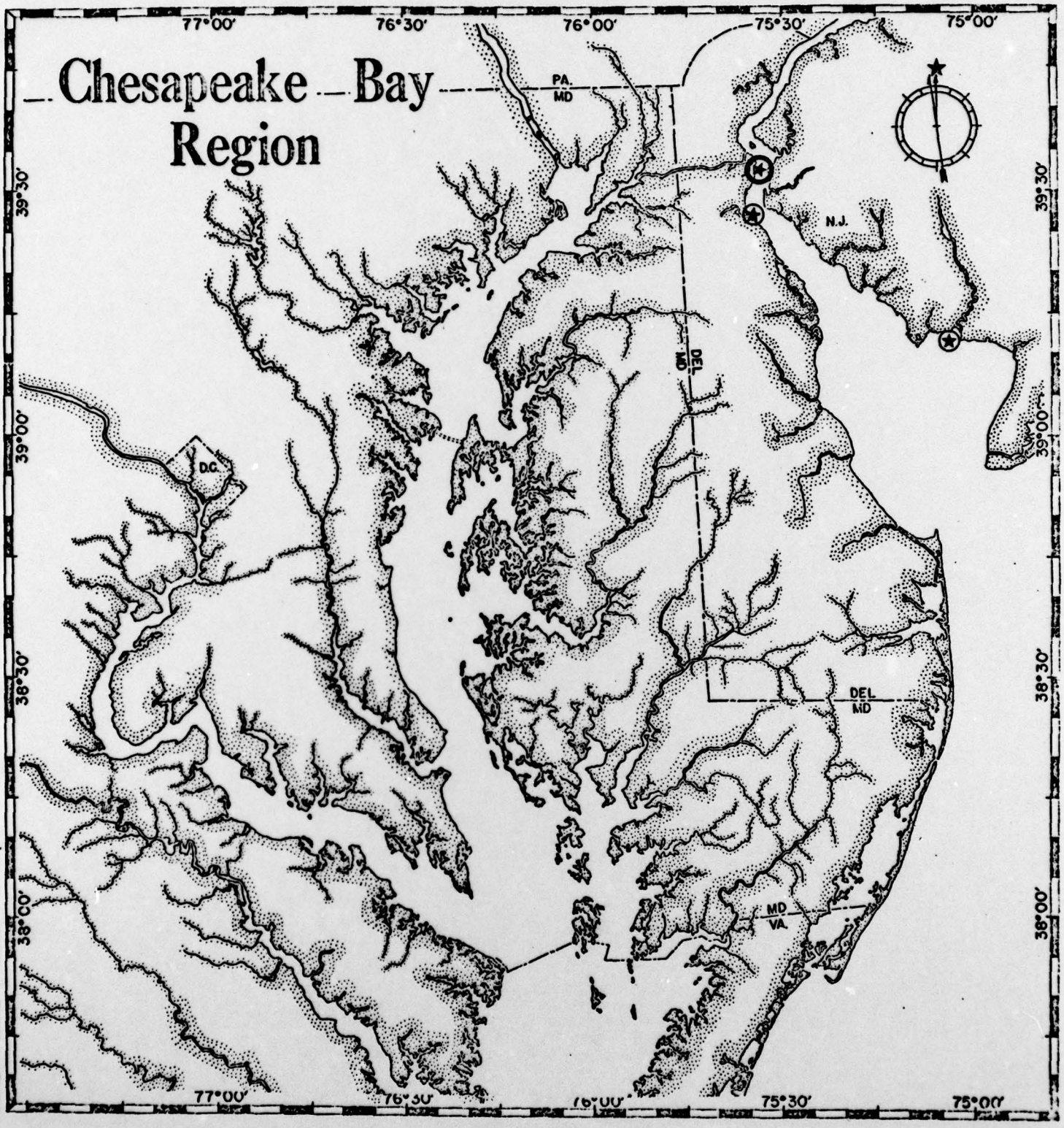

Fig. 5. Map showing results of recapture for crabs released at Site #2. Point of release marked by heavy circles; recapture sites marked by thin circles.

Release Site 2
Chesapeake City, Maryland

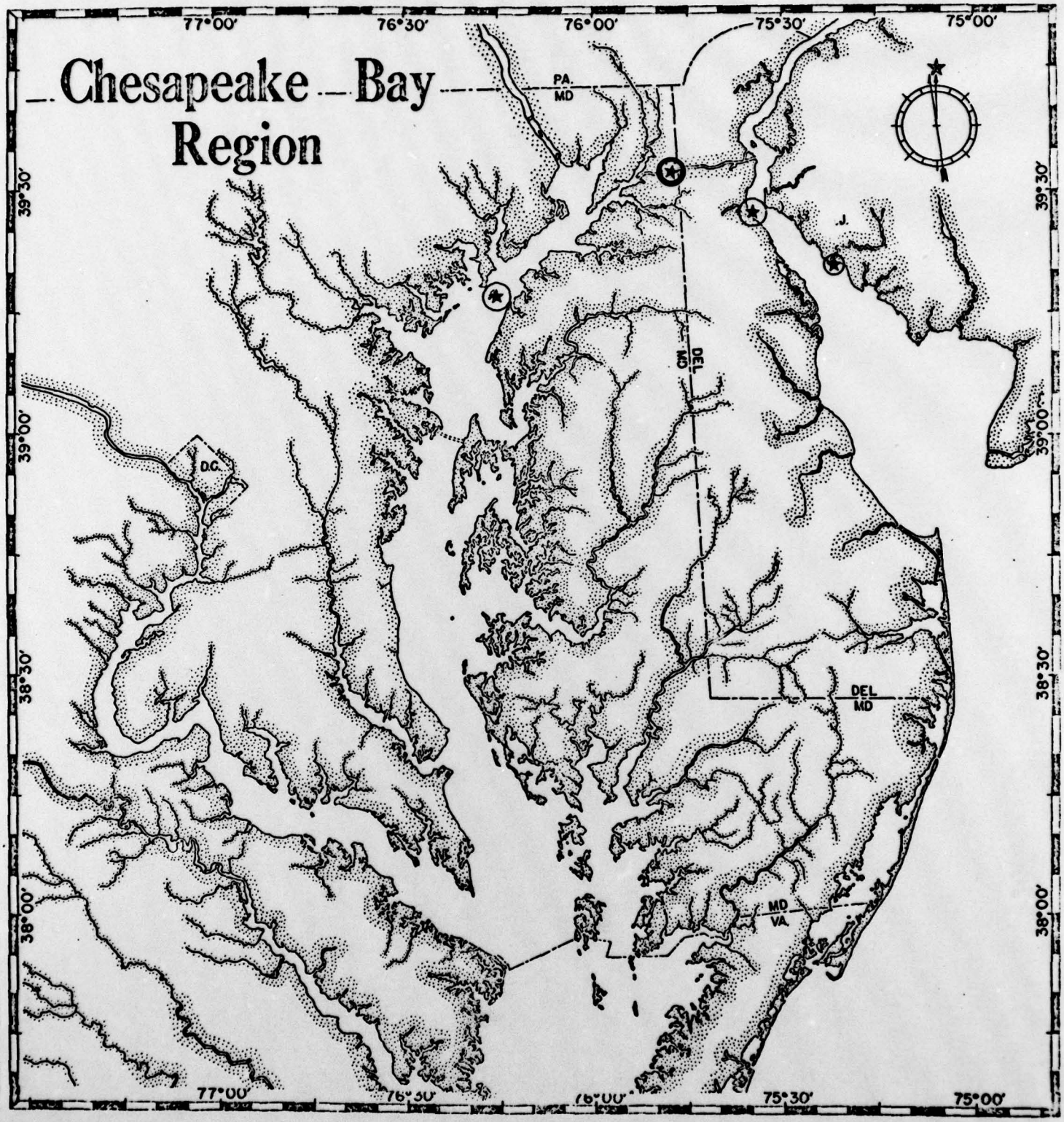

Fig. 6. Map showing results of recapture for crabs released at Site #3. Point of release marked by heavy circles; recapture sites marked by thin circles.

Release Site 3
C & D Canal Western Mouth, Md.

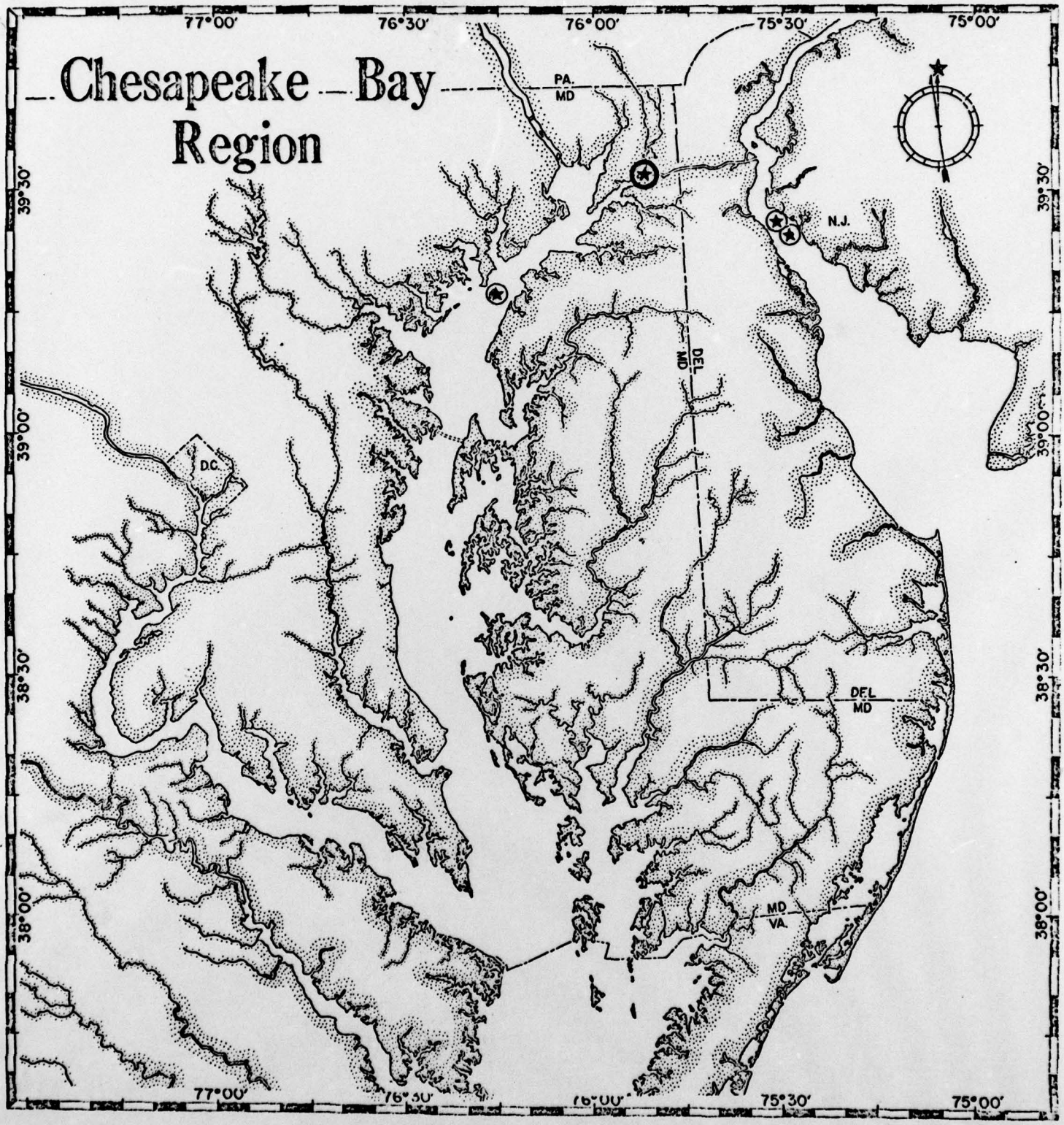

Fig. 7. Map showing results of recapture for crabs released at Site #4. Point of release marked by heavy circles; recapture sites marked by thin circles.

Release Site 4
Elk River, Md. N. of Turkey Pt.

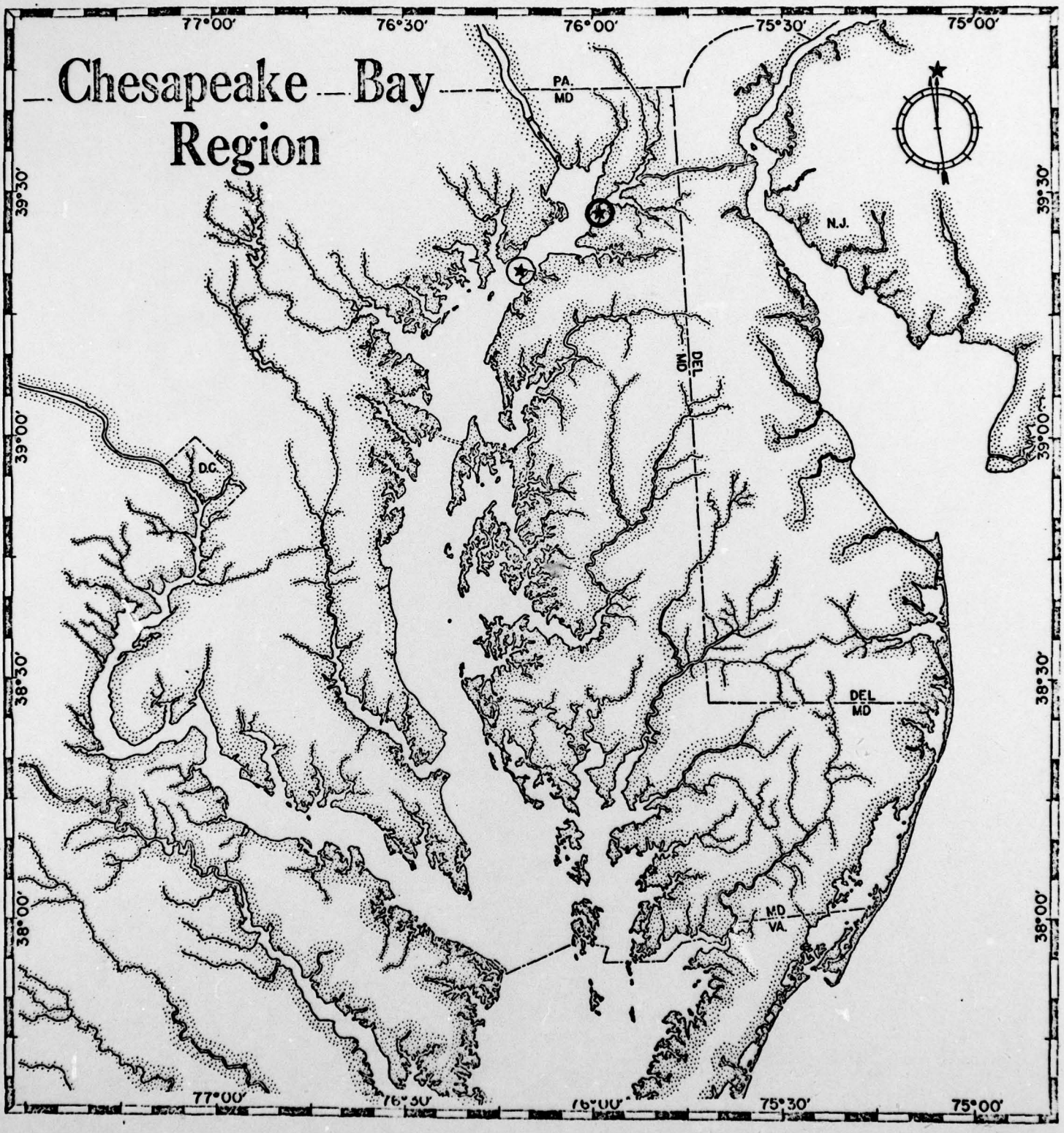

Fig. 8. Map showing results of recapture for crabs released at Site #5. Point of release marked by heavy circles; recapture sites marked by thin circles.

Release Site 5
Elk River, Md. Piney Creek Cove

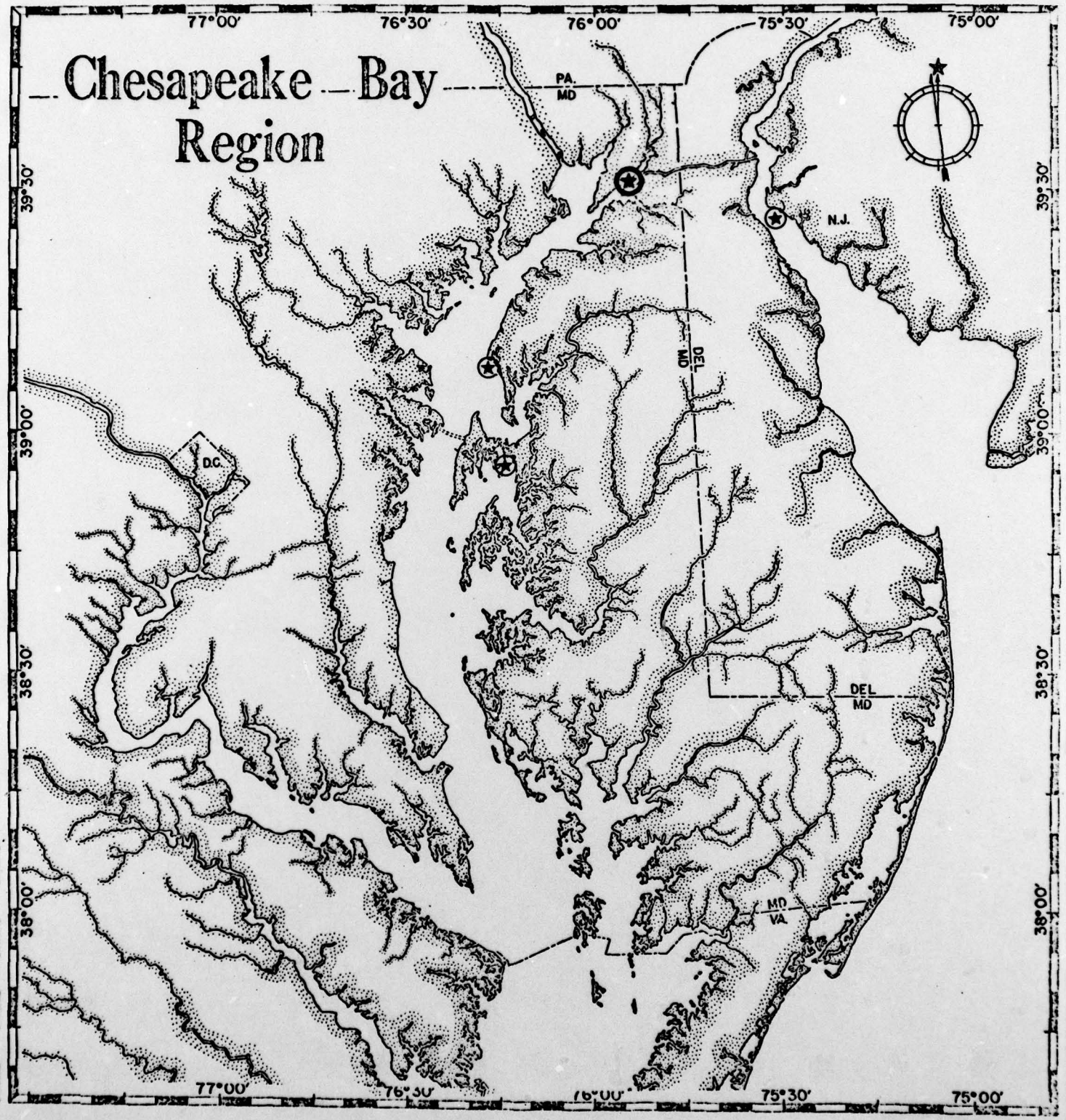

Fig. 9. Map showing results of recapture for crabs released at Site #6. Point of release marked by heavy circles; recapture sites marked by thin circles.

Release Site 6
C & D Canal Eastern Mouth Del. Bay